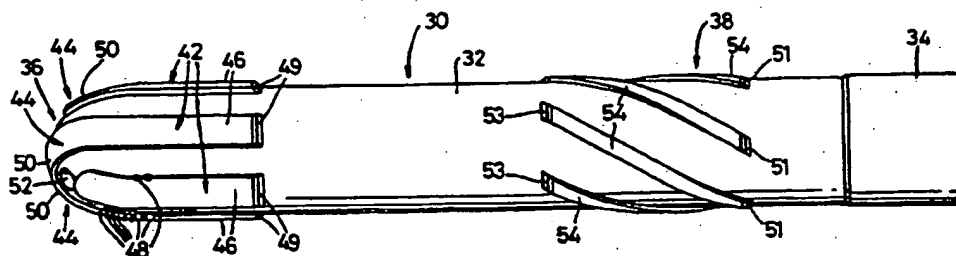


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(21) International Application Number: PCT/GB96/00556 (22) International Filing Date: 11 March 1996 (11.03.96) (30) Priority Data: 9504968.0 11 March 1995 (11.03.95) GB (71) Applicant (for all designated States except US): BRIT BIT LIMITED [GB/GB]; Units 2, 3 & 4, Logman Centre, Greenbank Crescent, East Tullos, Aberdeen AB1 4BG (GB). (72) Inventors; and (75) Inventors/Applicants (for US only): STRONG, Phillip [GB/GB]; Enterprise Oil plc, Victoria Tower, 62 Market Street, Aberdeen AB1 2PJ (GB). WARDLEY, Michael [GB/GB]; Northhill House, Northhill Park, Laurencekirk AB30 1EQ (GB). (74) Agent: MURGITROYD & COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: **IMPROVED CASING SHOE**

(57) Abstract

A casing shoe (30) for use in guiding a casing into a wellbore comprises a generally cylindrical body (32) having a box portion (34) at its rearward end for connection to a casing string and having a generally rounded nose portion (36) at its forward end. The forward end of the shoe includes cutting structures (42, 44) in the form of raised flutes extending along the sides of the cylindrical body and on the nose portion. The flutes may be provided with cutting elements such as polycrystalline diamond compact elements (48) at least at the forward ends of the flutes (42) extending along the cylindrical body. These flutes may also be configured to serve as stabilising pads, and additional stabilising pads (38) may also be provided. The nose portion may include fluid passages (50). The shoe may be adapted to be capable of being drilled through, such as by forming the nose portion from a drillable material. The provision of cutting structures on the casing shoe allows the tool to remove or negotiate obstacles which would prevent the passage of conventional casing shoes. The trailing ends of the various flutes may be provided with abrasive material to provide a back-reaming capability. The nose portion may also be eccentrically shaped to assist in negotiating obstacles.

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1 **"Improved Casing Shoe"**

2

3 The present invention relates to casing shoes of the
4 type used typically in wellbores or boreholes for
5 guiding a casing into the wellbore. The invention
6 relates more particularly to an improved casing shoe
7 adapted both to guide the casing into the wellbore and
8 to perform a degree of drilling and/or reaming of the
9 earth formation. Preferably, the casing shoe will not
10 obstruct the passage of subsequent tools into the well.

11

12 It is known, standard practice to use casing shoes for
13 the purpose of guiding a casing string into a wellbore.
14 An example of a typical casing shoe 10 is illustrated
15 in Fig. 1. When running a casing string into a
16 wellbore, the casing string requires a leading edge
17 capable of guiding the string since there may be
18 partial obstructions in the wellbore, such as ledges
19 for example. A standard casing shoe is adequate for
20 this purpose provided that the obstructions encountered
21 are not too severe.

22

23 The shoe shown in Fig. 1 comprises a generally
24 cylindrical steel casing 12 having an internally
25 threaded box portion 14 for connection to a

1 complementary pin portion of a casing string, and a
2 central portion 16 of drillable material (such as
3 cement, aluminium, plastics or the like) secured in the
4 interior of the casing 12 forward of the box portion 14
5 and having a generally rounded nose projecting
6 frontwards beyond the forward end of the casing 12. The
7 central portion 16 has a through-bore 18 to allow the
8 passage of fluids. A shoe of this type may incorporate
9 other, associated equipment, such as a unidirectional
10 ball-valve (not shown) in the bore 18, which inhibits
11 flow of mud from the wellbore into the casing string
12 whilst running the casing, but allows flow of cement
13 from the bore of the casing string into the annulus
14 between the casing string and the wellbore after the
15 full length of the casing string has been run into the
16 wellbore. The present invention may also incorporate
17 such additional, associated equipment.

18
19 An important feature of most casing shoes is that the
20 central portion 16 is drillable by standard oilfield
21 drill bits, since it may subsequently be necessary to
22 drill a further section of wellbore beyond the casing
23 shoe. However, there is also a requirement for casing
24 shoes which are not capable of being drilled through.

25
26 The advent in recent years of highly deviated or
27 horizontal wells in the oil industry has increased both
28 the frequency and seriousness of difficulties
29 encountered while running wellbore casing strings, to
30 the extent where a conventional casing shoe may be
31 unable to pass a particular obstruction in the
32 wellbore. Obstructions may arise from the bore of the
33 well itself swelling inwardly, as is sometimes the case
34 with hydratable shales for example, or when the
35 wellbore contains ledges caused by drilling through
36 rock formations of differing hardnesses, or due to the

1 accumulation of loose material in the wellbore being
2 ploughed up ahead of the casing shoe until further
3 progress is no longer possible.

4
5 This last situation is illustrated in Fig. 2, which
6 shows the casing shoe 10 of Fig. 1 attached to a casing
7 string 20 being run in a near-horizontal wellbore 22
8 surrounded by competent formation 24. The passage of
9 the casing shoe 10 along the wellbore 22 is obstructed
10 by an unconsolidated formation 26 of loose material.

11
12 The consequence of encountering such difficulties are,
13 at best, delays in the schedule of the well programme
14 and, at worst, having to drill all or part of the well
15 again. In any case, significant additional cost is
16 involved.

17
18 It is an object of the present invention to provide an
19 improved casing shoe which performs the string-guiding
20 function of standard casing shoes, but which is capable
21 of clearing obstructions which would halt the passage
22 of conventional shoes. In the preferred embodiments of
23 the invention, this involves the ability to ream
24 swelled sub-surface formations and/or to deal with
25 large quantities of unconsolidated solids, whilst
26 (preferably) allowing the subsequent passage of other
27 equipment.

28
29 In accordance with the present invention there is
30 provided a casing shoe comprising a generally
31 cylindrical body having a first end adapted for
32 connection to a casing string and having a second end
33 including a generally rounded nose portion, said casing
34 shoe further including cutting means adapted to ream,
35 drill, cut or displace obstacles encountered in use of
36 the casing shoe in a borehole.

1 Preferably, said cutting means includes cutting
2 structures disposed along the sides of said generally
3 cylindrical body and on said nose portion.

4
5 Preferably also, said cutting structures comprise a
6 plurality of raised flutes extending along at least a
7 portion of said cylindrical body and converging towards
8 the forward end of said nose portion.

9
10 Preferably also, said flutes are provided with cutting
11 elements such as polycrystalline diamond compact (PDC)
12 elements.

13
14 Preferably also, said cutting elements are located at
15 least on those portions of said flutes extending along
16 said cylindrical body adjacent said nose portion.

17
18 Preferably, rearward portions of said flutes extending
19 along the sides of said cylindrical body are configured
20 as stabilising pads.

21
22 Preferably also, the outer faces of said rearward
23 portions are provided with hard facing of tungsten
24 carbide or the like, and the trailing ends of said
25 rearward portions are provided with abrasive material,
26 such as aggressive tungsten carbide, to enable a degree
27 of back-reaming.

28
29 Preferably also, those portions of said flutes located
30 on said nose portion include cutting elements such as
31 tungsten carbide discs, shaped ceramics or angular
32 aggregate.

33
34 In one preferred embodiment, said cutting structures
35 include primary cutting structures including first
36 raised flutes extending along at least a portion of

1 said cylindrical body and terminating at said second
2 end thereof.

3

4 Preferably also, the forward ends of said cylindrical
5 body and of said first flutes taper inwardly to the
6 inner diameter of said cylindrical body, and said
7 forward ends of said first flutes include cutting
8 elements such as polycrystalline diamond compact (PDC)
9 elements.

10

11 Preferably, said cutting structures also include
12 secondary cutting structures located on said rounded
13 nose portion said secondary cutting structures
14 comprising extensions of said first flutes extending
15 from the ends of said first flutes towards the centre
16 of said nose portion.

17

18 In certain embodiments, at least a portion of the
19 interior bore of said cylindrical body adjacent said
20 second end contains an inner portion of drillable
21 material secured thereto, said rounded nose of the
22 casing shoe being formed by said inner portion
23 projecting beyond said second end of said cylindrical
24 body.

25

26 Preferably, said flute extensions of said secondary
27 cutting structures are formed integrally with said
28 rounded nose from the material of said inner portion.

29

30 The following features are preferably included in all
31 embodiments of the invention:

32

33 said nose portion may have at least one through
34 bore formed therein to communicate with the interior of
35 said cylindrical body;

36

1 the casing shoe may further include stabilising
2 means, suitably comprising a plurality of spiral
3 flutes, which may be formed integrally with the
4 cylindrical body of the casing shoe, or may be provided
5 on a separate cylindrical body adapted to be connected
6 between the casing shoe and a casing string; the outer
7 faces of said spiral flutes are preferably provided
8 with hard facing of tungsten carbide or the like, and
9 the trailing ends of said spiral flutes are provided
10 with abrasive material, such as aggressive tungsten
11 carbide, to enable a degree of back-reaming; the
12 forward ends of said spiral flutes are preferably
13 provided with abrasive material, such as aggressive
14 tungsten carbide, to protect the flutes from damage
15 during forward motion of the shoe.

16
17 Where the shoe is required to be capable of being
18 drilled through, the rounded nose portion may be formed
19 as a hollow structure capable of being drilled through,
20 deformed or displaced if required to enable subsequent
21 drilling operations.

22
23 In a further variation of the invention, the rounded
24 nose portion may be eccentrically shaped to assist in
25 negotiating obstructions.

26
27 Embodiments of the invention will now be described, by
28 way of example only, with reference to the
29 accompanying drawings in which:

30
31 Fig. 1 is a sectional side view of a conventional
32 casing shoe;

33
34 Fig. 2 is a sectional side view of the casing shoe
35 of Fig. 1 approaching an obstruction in a
36 wellbore;

1 Fig. 3 is a side view of an example of a casing
2 shoe embodying the present invention;

3
4 Fig. 4 is a sectional side view of the casing shoe
5 of Fig. 3;

6
7 Fig. 5 is a front end view of the casing shoe of
8 Figs. 3 and 4;

9
10 Fig. 6 is a side view of a further example of a
11 casing shoe embodying the present invention; and

12
13 Fig. 7 is a front end view of the casing shoe of
14 Fig. 6.

15
16
17 Referring now to the drawings, Figs. 3 and 4 show an
18 example of a casing shoe 30 in accordance with the
19 invention.

20
21 The shoe 30 comprises a generally cylindrical steel
22 casing 32 having an internally threaded box portion 34
23 at its tail end, for connection to a casing string (not
24 shown), and having a generally rounded nose portion 36
25 at its front end, as shall be described in greater
26 detail below. Optionally, the shoe 30 may also include
27 a stabiliser portion 38, as shall also be discussed in
28 greater detail below.

29
30 In this embodiment, the shoe 30 also includes a central
31 portion 40 of drillable material, the forward end of
32 which forms the rounded nose 36. This portion may be
33 of cement, aluminium, plastics or the like. The type
34 of material from which it is formed may depend upon the
35 type of drill bit which will be required to drill it
36 out, should this prove necessary.

1 In accordance with the invention, the forward end of
2 the shoe 30 is provided with cutting structures which
3 enable the tool to ream, drill, cut or displace
4 obstacles such as inward swellings of the competent
5 formation and/or accumulations of unconsolidated
6 solids. In this example, the shoe 30 includes primary
7 cutting structures extending along the sides of the
8 forward end of the shoe and intended primarily for
9 reaming inward swellings of the formation, and
10 secondary cutting structures, generally designated by
11 the numeral 44, incorporated in the rounded nose 36 and
12 intended primarily for the displacement of
13 unconsolidated solids.
14

15 The primary cutting structures comprise a plurality of
16 linear flutes 42 extending substantially parallel to
17 one another to the forward end of the casing 32 and
18 spaced equidistantly around the circumference thereof,
19 and having suitable cutting elements, such as
20 polycrystalline diamond compact (PDC) elements, set
21 into their lateral edges, as indicated at 48. As seen
22 in Fig. 4, the walls of the casing 32 are tapered
23 inwardly towards the forward end thereof and the
24 forward ends of the flutes 42 follow the tapered
25 contour of the casing walls and terminate at the inner
26 diameter of the casing 32. The PDC's 48 are located
27 along the tapered forward portions of the flutes 42.
28 The rearward portions 46 of the flutes 42 extending
29 along the sides of the casing 32 are configured as
30 stabilising pads and may be provided with hard facings
31 of material such as tungsten carbide. The trailing ends
32 of the flutes 46 may also be provided with abrasive
33 elements 49 of material such as aggressive tungsten
34 carbide, providing a back-reaming capability.
35

36 The secondary cutting structures 44 comprise contiguous

1 extensions 50 of the flutes 42, formed integrally with
2 the drillable material of the central portion 40 and
3 extending towards the centre of the rounded nose 36.
4 The configuration of the secondary cutting structures
5 44 is more clearly seen in Fig. 5. In this example
6 there are six primary flutes 42 and six corresponding
7 extensions 50, of which alternate extensions are
8 designated 50a in Fig. 5 and intervening extensions are
9 designated 50b. The alternate flute extensions 50a
10 converge at the centre of the nose 36, and the
11 intervening flute extensions 50b terminate outwardly of
12 the centre. Depending upon the type of obstructions
13 expected to be encountered by the secondary cutting
14 structures 44, cutting elements (not shown) such as
15 tungsten carbide discs, shaped ceramics or angular
16 aggregate might be incorporated therein, or cutting
17 might be performed by the flute extensions 50
18 themselves. Where the casing shoe is adapted to be
19 capable of being drilled through, as in this example,
20 it may be preferable to omit hard cutting elements from
21 the drillable portion of the nose, since such elements
22 may interfere with the drilling through of the tool.
23
24 One or more through bores 52 may be formed in the
25 central portion 40, to allow the passage of drilling
26 fluids, cement etc from the interior of the casing
27 string to the external annulus as may be required in
28 use of the shoe. In particular, the bores 52 allow the
29 passage of drilling fluid to flush away debris created
30 by the cutting action of the tool. The spaces between
31 the flutes 42, 50 of the primary and secondary cutting
32 structures also serve as fluid passages for fluid
33 between the tool face and the annulus between the
34 casing string and the borehole. In this example, there
35 are three bores 52, the forward ends of which are
36 disposed between the ends of the intervening flute

1 extensions 50b and the centre of the nose 36. If
2 required, the bores 52 may be fitted with valves etc.
3 (not shown) as in prior art casing shoes.

4
5 The optional stabiliser portion 38 may be used to
6 provide a particular directional response from the tool
7 or to act as a pivot point to assist the tool in
8 negotiating obstacles. In this example, the stabiliser
9 comprises a plurality of spiral flutes 54, formed
10 integrally with the casing 32. Alternatively, the
11 stabiliser could be provided as a separate component
12 (not shown), having its own threaded box and pin, which
13 can be connected between the shoe 30 and the casing
14 string. In this case the shoe itself could be
15 substantially shorter in length than the illustrated
16 example with its integral stabiliser 38.

17
18 The outer faces of said spiral flutes 38 may also be
19 provided with hard facing of tungsten carbide or the
20 like, as with the forward stabiliser pads 46, and their
21 trailing ends may also provided with abrasive elements
22 51, such as aggressive tungsten carbide, to assist
23 back-reaming. The forward ends of the spiral flutes 38
24 may similarly be provided with abrasive elements 53, to
25 protect the flutes 38 from damage during forward motion
26 of the shoe 30.

27
28 In a variation of this drillable embodiment of the
29 invention, the inner portion 40 might be omitted and
30 the rounded nose formed as a hollow structure designed
31 to be capable of being drilled through or displaced
32 forwardly and outwardly into a region defined
33 approximately by forward extension of the casing 32.
34 Such displacement would take place after the casing
35 string has been run to its full depth and before it has
36 been cemented in place. The displacement might suitably

1 take place as an integral part of the cementing
2 procedure. A hollow nose of this type might suitably
3 take the form of a segmented dome structure which is
4 plastically deformable in response to hydraulic
5 pressure associated with the injection of cement.
6 Alternatively, the dome segments might be hinged to the
7 forward end of the tubular casing 32. In either case,
8 the nose structure may include ribs or the like
9 providing the secondary cutting structures.

10

11 In a further variation, the nose portion of the tool
12 may be eccentrically shaped so as to impart a cyclic
13 lateral motion upon encountering an obstruction. This
14 may assist in negotiating such obstructions. Figs. 6
15 and 7 of the drawings show an example of a casing shoe
16 60 in accordance with the invention, having an
17 eccentrically shaped nose portion 62 of this type. The
18 cutting structures in this example comprise three
19 spiral flutes 64, 66, 68, converging at the forward end
20 of the nose portion 62. The flutes may be provided
21 with cutting elements (not shown) such as PDC cutters,
22 as required, and the shoe may include fluid passages,
23 having outlets 70, 72, 74 in the nose portion 62, as in
24 the previous embodiment.

25

26 The embodiment of Figs. 6 and 7 is also an example of a
27 "non-drillable" shoe; i.e. it does not include any
28 portion purposely designed to be capable of being
29 drilled through. The shoe has an internal blind bore
30 76, which terminates around the point where the
31 generally cylindrical body of the shoe begins to taper
32 to form the nose portion 62. Accordingly, the nose
33 portion 62 is solid, except for the fluid channels (not
34 shown) extending therethrough.

35

36 It will be appreciated that this embodiment could be

1 made to be drillable in a similar manner as the
2 previous embodiment and that, conversely, the drillable
3 embodiment of Figs. 3 - 5 could be made non-drillable
4 in the same way as that of Figs. 6 and 7. Also, the
5 embodiment of Figs. 6 and 7 could be modified to
6 incorporate an integral stabiliser portion, if
7 required. In non-drillable embodiments of the
8 invention, hard cutting elements may be located
9 anywhere on the nose portion as required.

10

11 The provision of cutting structures on the casing shoe
12 allows the tool to remove or negotiate obstacles which
13 would prevent the passage of conventional casing shoes.
14 Other features such as the stabiliser also assist in
15 the negotiation of obstacles.

16

17 Improvements or modifications may be incorporated
18 without departing from the scope of the invention.

19

20

21

1 Claims

2

3 1. A casing shoe comprising a generally cylindrical
4 body having a first end adapted for connection to a
5 casing string and having a second end including a
6 generally rounded nose portion, said casing shoe
7 further including cutting means adapted to ream, drill,
8 cut or displace obstacles encountered in use of the
9 casing shoe in a borehole.

10

11 2. A casing shoe as claimed in Claim 1, wherein said
12 cutting means includes cutting structures disposed
13 along the sides of said generally cylindrical body and
14 on said nose portion.

15

16 3. A casing shoe as claimed in Claim 2, wherein said
17 cutting structures comprise a plurality of raised
18 flutes extending along at least a portion of said
19 cylindrical body and converging towards the forward end
20 of said nose portion.

21

22 4. A casing shoe as claimed in Claim 3, wherein said
23 flutes are provided with cutting elements such as
24 polycrystalline diamond compact (PDC) elements.

25

26 5. A casing shoe as claimed in Claim 4, wherein said
27 cutting elements are located at least on those portions
28 of said flutes extending along said cylindrical body
29 adjacent said nose portion.

30

31 6. A casing shoe as claimed in any of Claims 3 to 5,
32 wherein rearward portions of said flutes extending
33 along the sides of said cylindrical body are configured
34 as stabilising pads.

35

36 7. A casing shoe as claimed in Claim 6, wherein the

1 outer faces of said rearward portions are provided with
2 hard facing of tungsten carbide or the like, and the
3 trailing ends of said rearward portions are provided
4 with abrasive material, such as aggressive tungsten
5 carbide, to enable a degree of back-reaming.

6
7 9. A casing shoe as claimed in any one of Claims 3
8 to 7, wherein those portions of said flutes located on
9 said nose portion include cutting elements such as
10 tungsten carbide discs, shaped ceramics or angular
11 aggregate.

12
13 10. A casing shoe as claimed in any one of Claims 3 to
14 9, wherein said cutting structures include primary
15 cutting structures including first raised flutes
16 extending along at least a portion of said cylindrical
17 body and terminating at said second end thereof.

18
19 11. A casing shoe as claimed in Claim 10, wherein the
20 forward ends of said cylindrical body and of said first
21 flutes taper inwardly to the inner diameter of said
22 cylindrical body, and said forward ends of said first
23 flutes include cutting elements such as polycrystalline
24 diamond compact (PDC) elements.

25
26 12. A casing shoe as claimed in Claim 10 or Claim 11,
27 wherein said cutting structures also include secondary
28 cutting structures located on said rounded nose portion
29 said secondary cutting structures comprising extensions
30 of said first flutes extending from the ends of said
31 first flutes towards the centre of said nose portion.

32
33 13. A casing shoe as claimed in any preceding Claim,
34 wherein at least a portion of the interior bore of said
35 cylindrical body adjacent said second end contains an
36 inner portion of drillable material secured thereto,

1 said rounded nose of the casing shoe being formed by
2 said inner portion projecting beyond said second end of
3 said cylindrical body.

4

5 14. A casing shoe as claimed in Claim 13 when
6 dependent from Claim 12, wherein said flute extensions
7 of said secondary cutting structures are formed
8 integrally with said rounded nose from the material of
9 said inner portion.

10

11 15. A casing shoe as claimed in any preceding Claim,
12 wherein said nose portion has at least one through bore
13 formed therein to communicate with the interior of said
14 cylindrical body.

15

16 16. A casing shoe as claimed in any preceding Claim,
17 further including stabilising means.

18

19 17. A casing shoe as claimed in Claim 16, wherein said
20 stabilising means comprises a plurality of spiral
21 flutes.

22

23 18. A casing shoe as claimed in Claim 17, wherein said
24 spiral flutes are formed integrally with the
25 cylindrical body of the casing shoe.

26

27 19. A casing shoe as claimed in Claim 17, wherein said
28 spiral flutes are provided on a separate cylindrical
29 body adapted to be connected between the casing shoe
30 and a casing string.

31

32 20. A casing shoe as claimed in any one of Claims 17
33 to 19, wherein the outer faces of said spiral flutes
34 are provided with hard facing of tungsten carbide or
35 the like, and the trailing ends of said spiral flutes
36 are provided with abrasive material, such as aggressive

1 tungsten carbide, to enable a degree of back-reaming.

2

3 21. A casing shoe as claimed in any one of Claims 17
4 to 20, wherein the forward ends of said spiral flutes
5 are provided with abrasive material, such as aggressive
6 tungsten carbide, to protect the flutes from damage
7 during forward motion of the shoe.

8

9 22. A casing shoe as claimed in any preceding Claim,
10 wherein said rounded nose portion is formed as a hollow
11 structure capable of being drilled through, deformed or
12 displaced if required to enable subsequent drilling
13 operations.

14

15 23. A casing shoe as claimed in any preceding Claim,
16 wherein said rounded nose portion is eccentrically
17 shaped to assist in negotiating obstructions.

18

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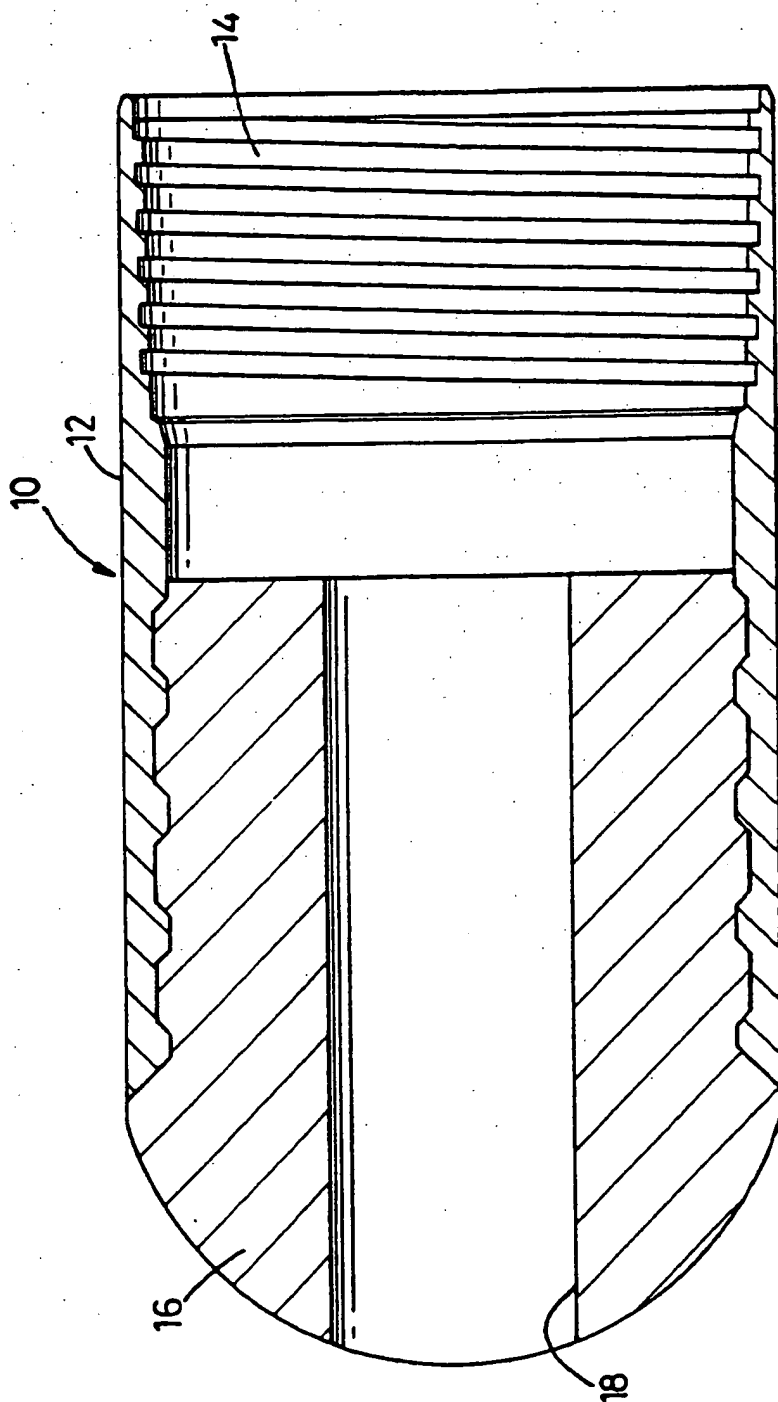


Fig. 1
(PRIOR ART)

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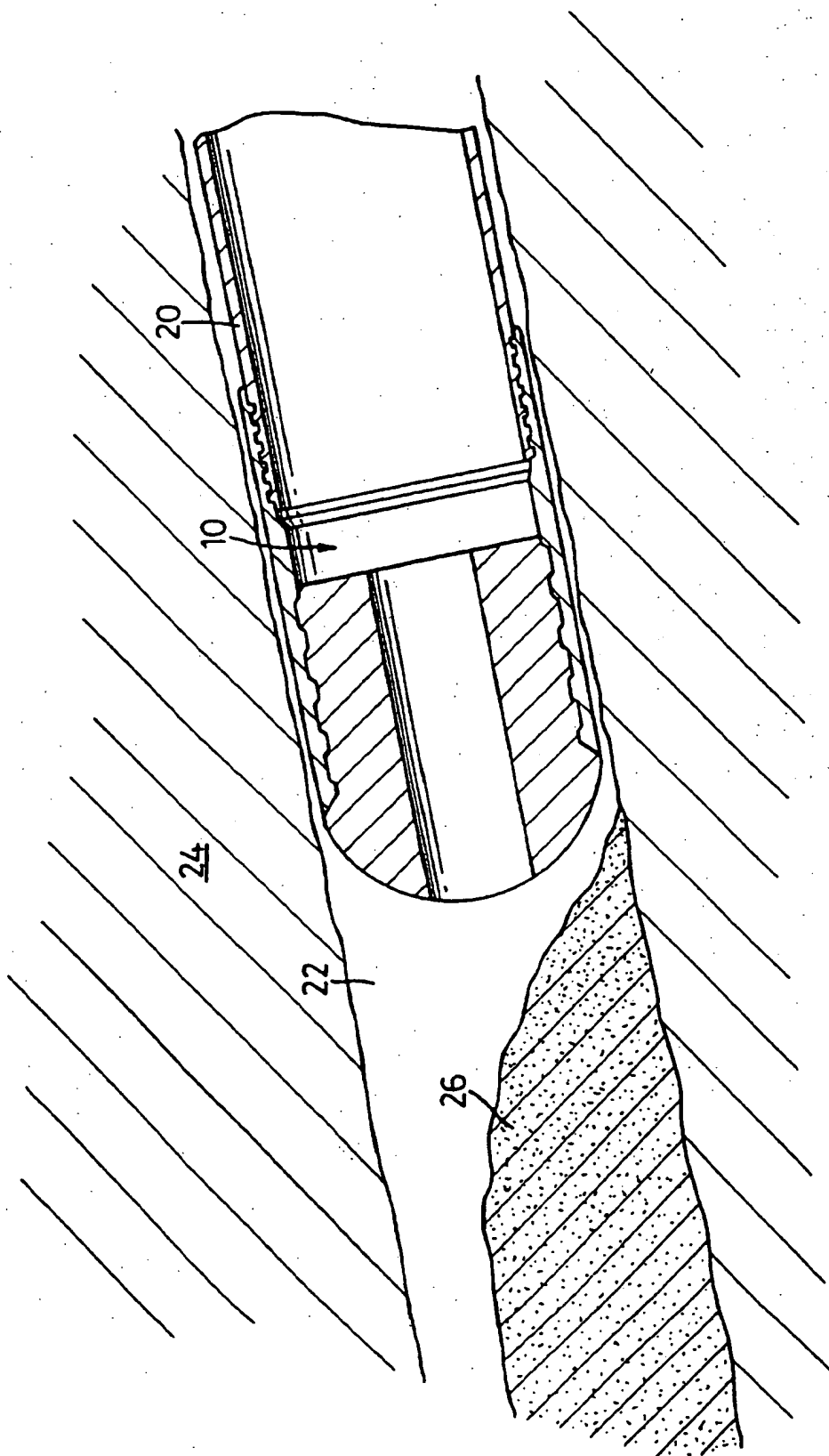


Fig. 2

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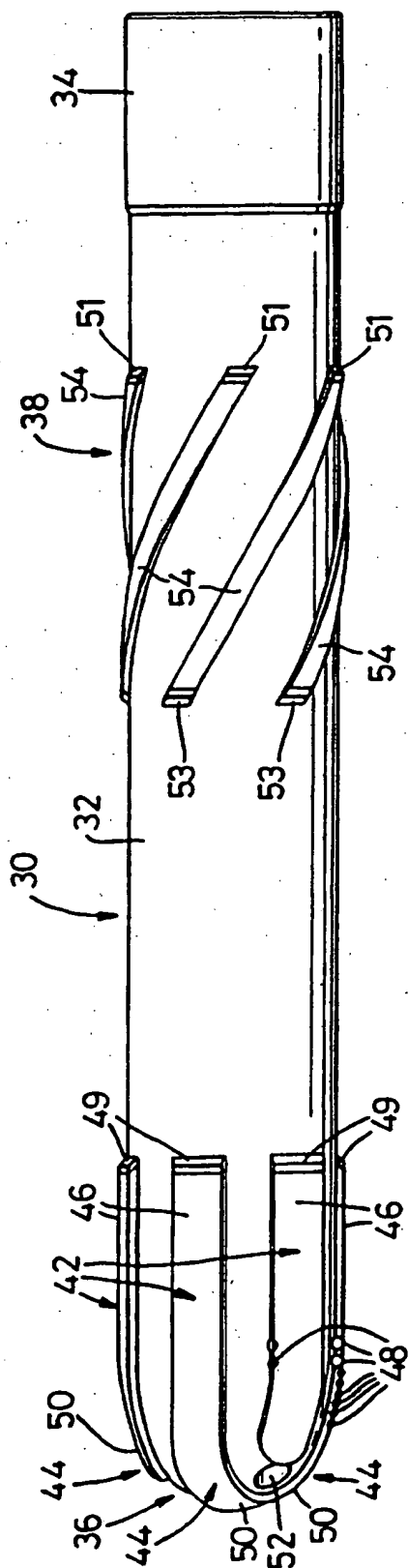


Fig. 3

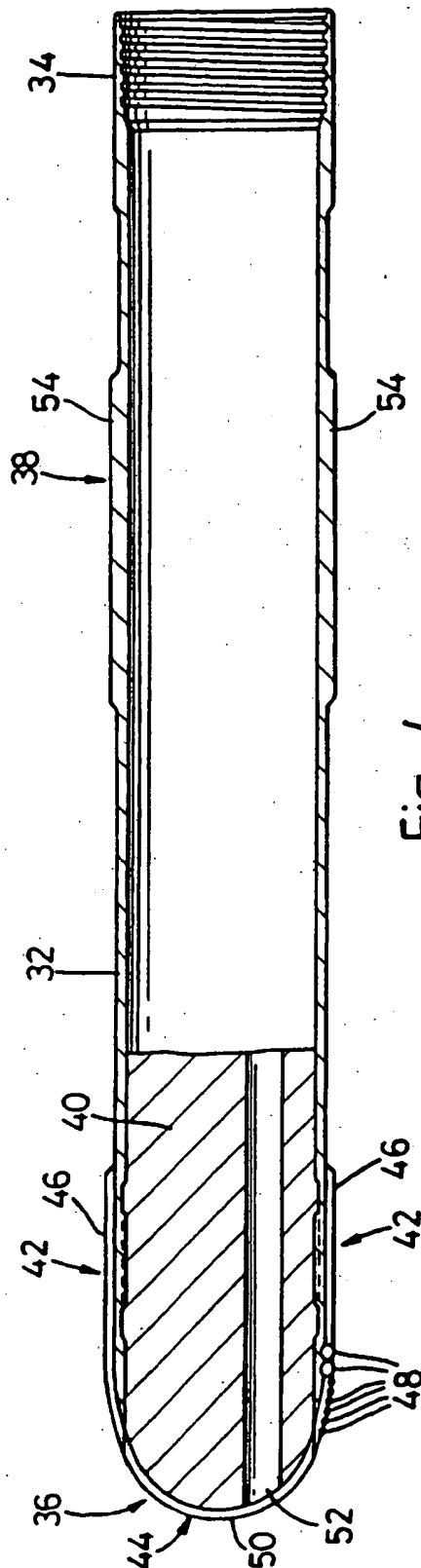


Fig. 4

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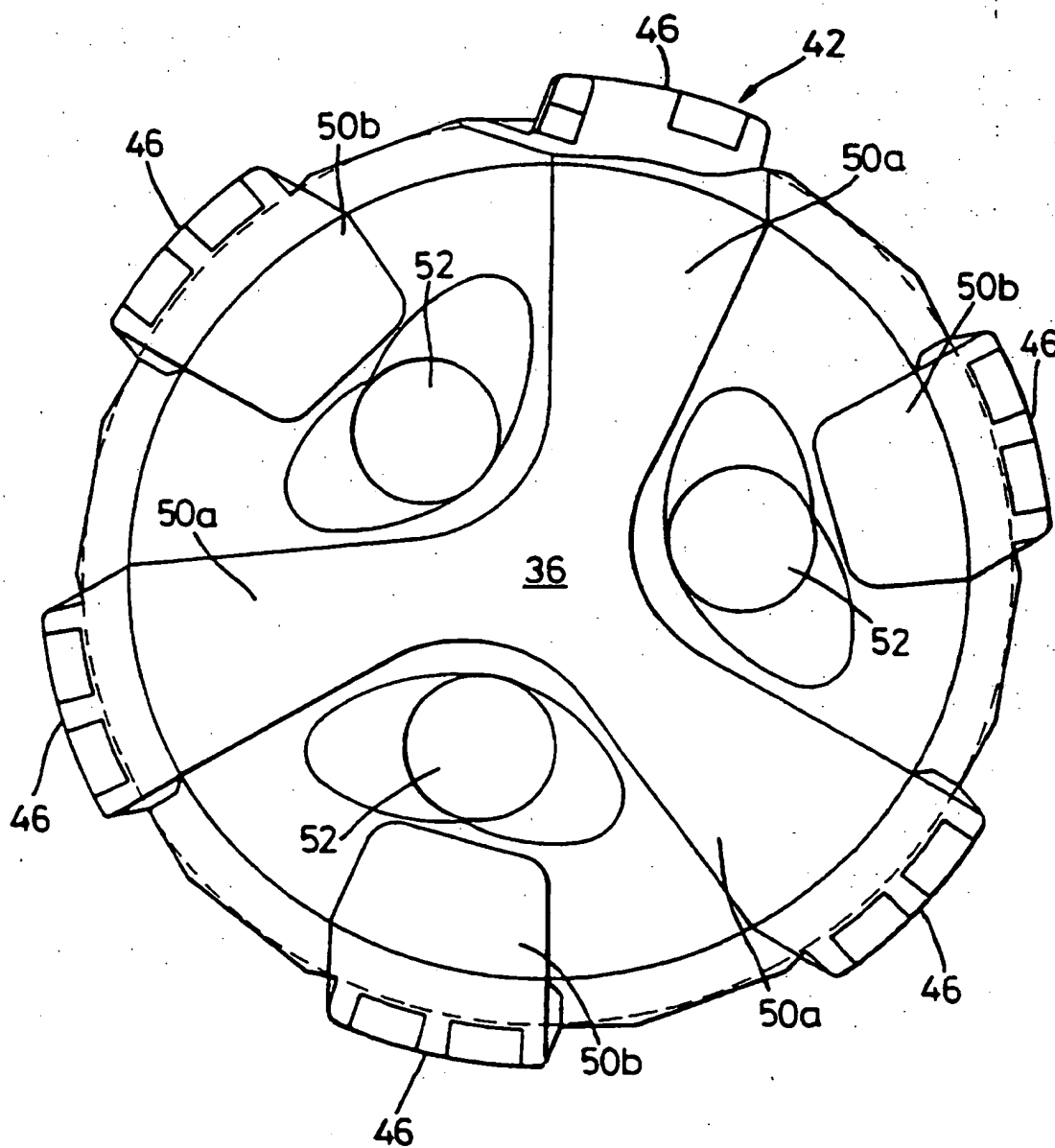


Fig. 5

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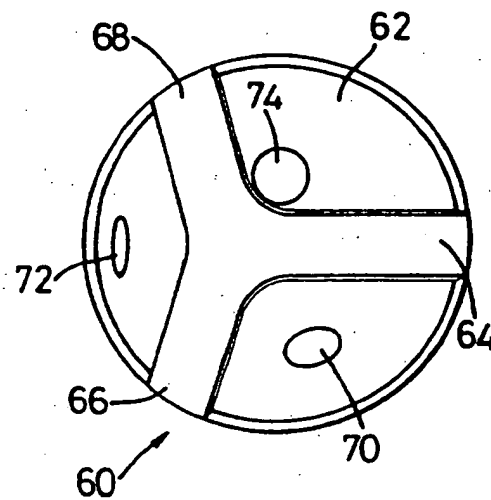
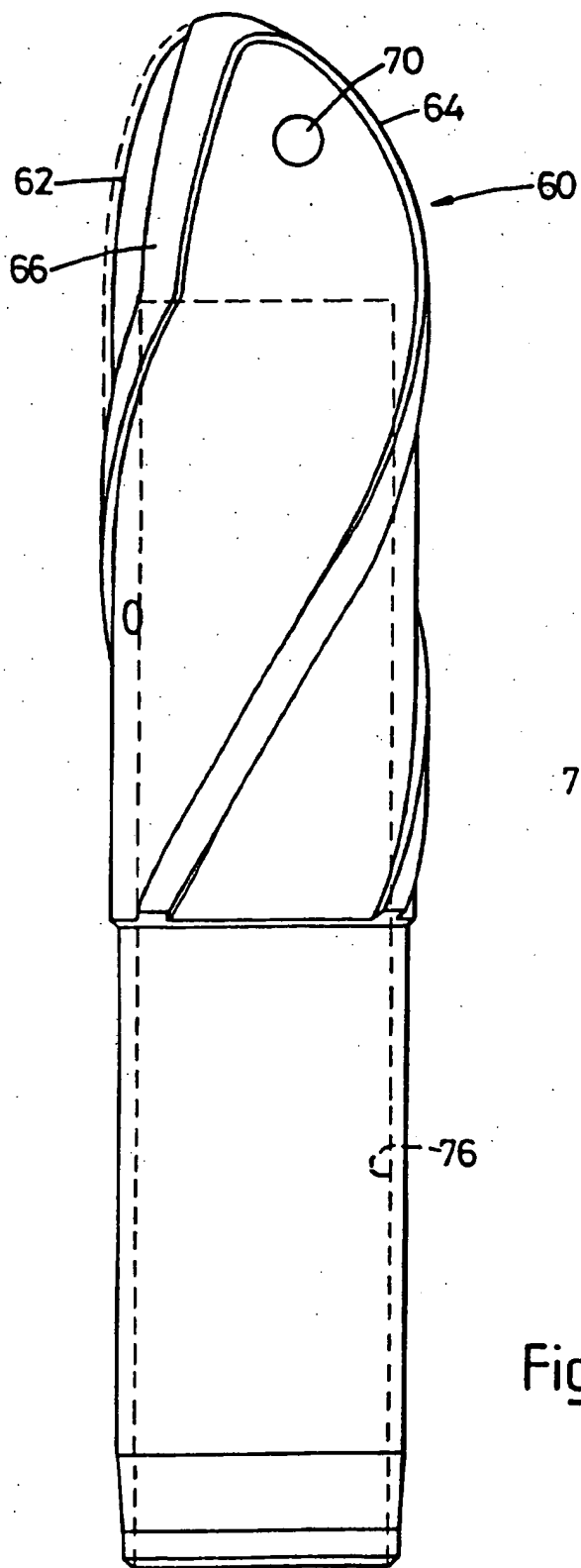


Fig. 7

Fig. 6

INTERNATIONAL SEARCH REPORT

Inter nal Application No

PCT/GB 96/00556

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B17/14 E21B17/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US,A,2 334 788 (O'LEARY) 23 November 1943 see page 1, left-hand column, line 32 - line 42; figures see page 2, right-hand column, line 74 - page 3, left-hand column, line 34 ---	1,15,22 2,13, 16-18, 20,21,23
Y	CA,A,1 222 448 (BRALORNE RESOURCES LTD) 2 June 1987 see claim 1; figures ---	2
Y	GB,A,2 170 528 (SEABOURN) 6 August 1986 see abstract; figures ---	13
Y	US,A,5 289 889 (GEARHART) 1 March 1994 see abstract; figures ---	16-18, 20,21
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

2 July 1996

Date of mailing of the international search report

15.07.96

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/00556

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO,A,93 25794 (PANTHER OIL TOOLS) 23 December 1993 see abstract; figures ---	20
Y	US,A,4 618 010 (FALGOUT) 21 October 1986 see abstract; figures ---	21
Y	US,A,3 266 577 (TURNER) 16 August 1966 see claim 1; figures ---	23
A	EP,A,0 028 121 (FLETCHER) 6 May 1981 see abstract; figures -----	1

INTERNATIONAL SEARCH REPORT

Int. l. Application No

PCT/GB 96/00556

Patent document cited in search-report	Publication date	Patent family member(s)	Publication date
US-A-2334788	23-11-43	NONE	
CA-A-1222448	02-06-87	NONE	
GB-A-2170528	06-08-86	NONE	
US-A-5289889	01-03-94	NONE	
WO-A-9325794	23-12-93	AU-B- 4342493	04-01-94
US-A-4618010	21-10-86	NONE	
US-A-3266577	16-08-66	NONE	
EP-A-28121	06-05-81	GB-A, B 2062726	28-05-81
		US-A- 4362217	07-12-82